Translation of
Japanese Laid-open (Kokai) Patent Application HEI 8-7614

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Title:	Sheet-like light source

Abstract

Purpose

To realize a sheet-like light source which uses (a) blue light emitting diode(s) and has white [light emission] capability, and furnish a sheet-like light source whereby it is possible to observe uniform emission of white light.

Constitution

A light emitting diode 1 is optically connected with an end face of a transparent light conductive plate 2, said light conductive plate 2 having on one of its major surfaces a diffusion layer 3 on which white powder diffusing fluorescence is applied, on the major surface of the light conductive plate 2 on the side opposite from the diffusion layer 3 a transparent film 6 is provided, and on this film 6 a fluorescent material is provided which is excited by the light emitted from the light emitting diode 1 so as to emit fluorescence.

What is claimed is:

(1) A sheet-like light source, characterized in that

a blue light emitting diode 1 is optically connected with at least one location in an end face of a transparent light conductive plate 2, said light conductive plate 2 moreover has on one of its major surfaces a diffusion layer 3 on which white powder is applied, on the major side of said light conductive plate 2 on the side opposite from said diffusion layer 3 a transparent film 6 is provided, and said film 6 includes on its surface or inside a fluorescent material which is

excited by light emitted from said blue light emitting diode 1 so as to emit fluorescent light.

(2) A sheet-like light source in accordance with Claim 1, characterized in that minute irregularities [lit.: depressions and protrusions] are provided on that surface of said film which contacts said transparent light conductive plate.

Detailed description of the invention

0001 Field of industrial application

The present invention relates to a sheet-like light source for use in display backlighting, illuminated operating switches etc., and in particular to a sheet-like light source suitable for use as a back light for liquid crystal displays.

0002 Prior art

As sheet-like light sources for liquid crystal backlighting applications in notebook-type personal computers and word processors etc., for example EL [electroluminescence] or cold cathode tubes are generally used. EL substantially is a sheet-like light source while cold cathode tubes are made into sheet-like light sources with the aid of a diffusion or scattering plate, with the color of the light emitted by these types of back light being mostly white at present.

0003 On the other hand, light-emitting diodes (hereinafter referred to as LEDs) are also partly employed as backlight-type light sources. When producing white color light emission by using LEDs, however, as the light output power of blue LEDs hitherto is only in the order of several tens of μW, in realizing white light emission by using other red or green LEDs, there is the drawback that it is difficult to harmonize the properties of the LEDs emitting these various colors, with color variations being large. Even when three primary color LEDs are combined by arranging them in geometrically identical positions in a same plane, it was moreover impossible to make them into a uniform white light source as a backlight because the individual LEDs were discernible in adjacent locations. Accordingly, the current situation is that cold cathode tubes for large formats and EL for small and medium-sized formats are presently used separately for white liquid crystal backlighting sheet-like light sources, with back light emitting white light by using LEDs hardly being known.

0004 There have also been attempts, as light sources for the emission of white or monochrome light, to make color changes by partly surrounding the periphery of a blue LED chip with resin including a fluorescent material, however due to a light beams having a radiation intensity at the periphery of the chip which is higher than that of sunlight, degradation of the fluorescent material turned out to be a problem which was particularly conspicuous with organic fluorescent pigments. In the case of ionic organic pigments, electrophoresis moreover occurs in the vicinity of the chip owing to dc. electric fields, so that there is the possibility of color tone variations. Conventional blue LEDs do not possess sufficient output power for making color tone changes by means of fluorescent pigments, and are consequently not suitable for practical use even when color changes are carried out.

0005 Problem points to be solved by the invention

In the present invention, which was conceived in order to solve these problems, the main object is to realize a sheet-like light source usable for use in backlighting and permitting emission of white light by using LEDs, at the same time to furnish a sheet-like light source which makes it possible to observe emission of white light, and in addition to furnish a sheet-like light source employing the excellent reliability properties of LEDs for use in any type of operating switches etc., which permits the of emission not only of white light but of light having any color.

0006 Measures for attaining the objectives

The sheet-like light source of the present invention is characterized in that a blue light emitting diode 1 is optically connected with at least one location in the end face of a transparent light conductive plate 2, moreover said light conductive plate 2 has on one of its major surfaces (hereinafter, the major surface on the side of the diffusion layer shall be referred to as the second major surface) a diffusion layer 3 with white-colored powder applied to it, on the major side of said light conductive plate 2 on the side opposite from said diffusion layer 3 (hereinafter referred to as the first major surface) a transparent film 6 is arranged, said film 6 having provided on its surface or inside a fluorescent material which is excited by light emitted from said blue light emitting diode 1 so as to emit fluorescence.

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Fig. 1 is a plan view of the light conductive plate 2 of the sheet-like light source according to the invention when viewed from the second major surface. The light conductive plate 2 consists of a transparent material such as acrylic resin, glass or the like, and the light conductive plate 2 and a blue LED 1 are optically connected by burying the blue LED 1 in an end face of this light conductive plate 2. In the present invention, optical connection between the blue LED 1 and the end face of the light conductive plate 2 means in simple terms that light from the blue LED is introduced from an end face of the light conductive plate 2; it is, of course, possible to connect the blue LED, for example, by burying the blue LED 1 as represented in this figure, and furthermore it is practically possible to realize conduction of light emitted by the blue LED to the light conductive plate 2 by using optical fiber etc..

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Next, the diffusion layer 3 diffuses the light into the light conductive plate 2 with the aid of a white pigment. Particularly in Fig. 1 the diffusion layer 3 is made stripe-shaped, with a pattern being formed so as to make the surface brightness on the side of the first major surface uniform by decreasing the surface per unit surface of the diffusion layer on the side of the second major surface with a decreasing distance from the LED 1; and the surface of the end portion of the second major surface farthest removed from the LED 1 is made to be slightly less than the maximum surface. The black squares in Fig. 1 indicate the pattern of diffusion layer 3. In Fig. 1 a configuration is realized where six blue LEDs are arranged in one end portion, but when the light conductive plate is rectangular, LEDs may, of course, be connected in all four end faces, so that the number of LEDs is not limited. In accordance with the layout conditions of the LEDs it is furthermore possible to suitably change the coating shape and condition of the diffusion layer 3 so as to make the light emission observed from the first major surface uniform.

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Function

Fig. 2 is a schematic sectional view showing an exemplary embodiment of the sheet-type light source of the present invention as a liquid-crystal panel backlight. That is, on the side of the second major surface of the sheet-type light source shown in Fig. 1, a reflection plate is arranged which is comprised of a diffusion reflection layer 7 consisting, for example, of barium titanate, titanium oxide,

aluminum oxide, and a base 8 for example of Al, which are laminated together, and on the side of the first major surface a transparent film 6 having minute irregularities provided on its surface is arranged, with a fluorescent material which emits fluorescent light when excited by the emitted light of the blue LED 1 being applied on the surface of this film 6 that is provided with the irregularities.

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At first, as is indicated by the arrows in Fig. 2, a part of the light exiting from the blue LED 1 in the vicinity of its chip is radiated to outside the light conductive plate 2, however the major part of the light is subjected to repeated complete reflection inside the light conductive plate 2 and reaches the end face of the light conductive plate 2. The light which reaches the end face is reflected by the reflection film 4 formed all over the end face and repeats complete reflection. At this time, owing to the diffusion layer 3 arranged on the second major surface of the light conductive plate 2, the light is diffused, with a part of the diffused light being absorbed by the fluorescent layer 5 and radiated off while at the same time undergoing wavelength conversion, so that the color of emitted light observed from the first major surface of the light conductive plate 2 is a combination of this light. For example in the case of a sheet-like color source that is provided with a fluorescent layer 5 consisting of orange-colored fluorescent pigment, the color of the light from the blue LED 1 can be observed to be white owing to the above related effect.

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In particular, in the present invention the main peak of the wavelength of light emitted from the blue LED is shorter than 500 nm, with a required light output power of more than 200 μW, particularly preferably more than 300 μW. The reason for this is that when the wavelength of emitted light is in excess of 500 nm, it becomes difficult to realize all colors, and when the light output power is less than 200 μW on the other hand, the possibility of achieving a light source having uniform surface-type light emission with sufficient brightness decreases even when, for example, the number of blue LEDs optically connected with the end face of the light conductive plate is increased.

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In patent application HEI 5-318267, the present inventors proposed a sheet-like light source whereby uniform emission of white light is possible, by forming a

fluorescent light scattering layer on the side of the major surface of the light conductive plate on the side opposite from where emission of light is observed. However in order to change the color tone in the sheet-like light source obtained with this method, it was necessary to peel off the fluorescent diffusion layer formed on the light conductive plate and again apply a fluorescence diffusion layer so as to achieve the desired color tone. In the present invention, on the other hand, because the fluorescent layer 5 and the diffusion layer 3 are independent of each other, particularly the fluorescent layer 5 which determines the color tone is formed on a film which may be pulled off, it is possibly to easily change the color tone by simply exchanging the film having the fluorescent layer 5 formed on it. Furthermore it is at the same time possible to separately emit light with a plurality of colors.

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The irregularities which are provided on the surface of the film 6 contacting the first major surface are very useful for diffusing the emitted light, and in addition it is possible to avoid adhesion of the film 6 to the light conductive plate 2 and the formation of interference patterns.

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Embodiments

First embodiment

On one surface of an acrylic resin plate having a thickness of approx. 2 mm, a diffusion layer 3 was formed in the stripe-shaped pattern shown in Fig. 1 by screen printing. The diffusion layer 3 was formed by imprinting with a white material consisting of barium titanate dispersed in an acrylic binder.

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The acrylic resin plate formed into the diffusion layer 3 in the above described manner was cut according to the desired pattern, and after polishing all the end faces (cut surfaces) of the acrylic resin plate, a light conductive plate 2 with diffusion layers 3 formed was obtained by forming a reflection layer 4 of Al on the ground surfaces.

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Next, a fluorescent layer 5 was formed on the film 6 having minute irregularities provided on its surface. The fluorescent layer 5 was formed by applying a

fluorescent pigment comprised of a mixture of equal parts of FA-001 by Sinloihi Chemical, which is a red fluorescent pigment, and FA-005 by the same company, which is a green fluorescent pigment, dispersed in an acrylic binder.

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In the end faces of the light conductive plate 2, holes were provided in six locations; and one blue LED 1 each consisting of a gallium nitride compound semiconductor having a light emission wavelength of 480 nm and a light output power of 1,200 μW was buried in these holes. When subsequently a light source for backlighting was produced by applying on the side of the surface for observing emitted light the film 6 having the fluorescent layer 5 formed on it in the above described manner, and providing on the side of diffusion layer 3 a reflection plate having a barium titanate layer 7 layer applied on an Al-base 8, a perfectly sheet-type, uniform white light emission from the first major surface was obtained. The luminance was 55 cd/m².

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Second embodiment

As a yellow fluorescent pigment, Lumogen F Yellow-083 by BASF, and as an orange-colored fluorescent pigment, Orange-240 by the same manufacturer were mixed in about identical amounts, and these and acrylic resin fluorescent pigment dissolved in butyl carbitol acetate were applied on the film 6 having minute irregularities. When a sheet-type light source according to the invention was then produced in otherwise the same way as in embodiment 1, a nearly uniform sheet-like light emission was observed. When a light source for backlight purposes was furthermore produced in this manner, a perfectly uniform, surface-type light emission was observed.

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Effects of the invention

As was explained above, with the sheet-type light source of the present invention uses blue LEDs, and furthermore includes a diffusion layer 3 having white powder applied on it on the side of one major surface of the light conductive plate and a transparent film having a fluorescent material provided on it on the side of the other major surface, which makes it possible to change the wavelength from the blue LEDs on it, it became possible as a result to realize a sheet-like light source through LEDs which have excellent reliability. Moreover as the

white powder of the diffusion layer 3 has the effect of reflecting and diffusing the light emitted from the blue LED, it is sufficient to use a small amount of fluorescent material. By forming minute irregularities on the film 6, the effect of diffusing the light is increased, and it is possible to prevent the film from sticking to the light conductive plate 2 and avoid interference patterns. It is moreover advantageous that, as the LED chip and the fluorescent material are not in direct contact with each other, the fluorescent material is not degraded, and color tone variations of the sheet-like light source do not occur over long periods of time. Moreover as regards color tone, owing to the kind of fluorescent material of the fluorescent layer 5 it is possible to furnish any desired color tone including white, and because the fluorescent material is present on the film, the color tone of the sheet-like light source can be changed easily by exchanging the film.

0020 As regards excitation of the fluorescent layer 5, on the other hand, it is most preferred to have a light output power of the used blue LED of more than 200 μm, for hereby it is made possible to realize a large-surface, bright sheet-like light source where wavelength conversion is effectively performed by the fluorescent material. In this way, the sheet-like light source of the present invention may be used not only as a light source for back light but also for illuminated operating switches etc. using fluorescent material.

Short explanation of the figures

Fig. 1 is a plan view of the light conductive plate 2 of the sheet-like light source of the first embodiment of the present invention when viewed from the side of diffusion layer 3.

Fig. 2 is a schematic sectional view of the sheet-like light source of the first embodiment of the present invention having the form of a back light.

Explanation of reference numerals

1 Blue LED
2 Light conductive plate
3 Diffusion layer
4 Reflection layer
5 Fluorescent layer
6 Film
7 Diffusion reflection layer

8 Al base

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[0004] There have also been attempts, as light sources for the emission of white or monochrome light, to make color changes by partly surrounding the periphery of a blue LED chip with resin including a fluorescent material, however due to a light beams having a radiation intensity at the periphery of the chip which is higher than that of sunlight, degradation of the fluorescent material turned out to be a problem which was particularly conspicuous with organic fluorescent pigments. In the case of ionic organic pigments, electrophoresis moreover occurs in the vicinity of the chip owing to dc. electric fields, so that there is the possibility of color tone variations. Conventional blue LEDs do not possess

sufficient output power for making color tone changes by means of fluorescent material, and are consequently not suitable for practical use even when color changes are carried out.

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